Streamlining Information Transfer between Construction and Structural Engineering
Edited by Shiau, J., Vimonsatit, V., Yazdani, S., and Singh, A.

ISBN: 978-0-9960437-7-9

UNBURNT CARBON REMOVED FROM FLY ASH BY FLOTATION METHOD

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Because fly ash has pozzolanic activity, it has been used for a long time as an admixture for concrete. However, unburnt carbon in the fly ash adversely affects the fresh properties of concrete. For this reason, when fly ash having a high unburnt carbon content is used as an admixture for concrete, it is desired to reduce the amount of unburnt carbon. So far, at our university, we have developed a technique to remove unburnt carbon by flotation method. It is necessary to add a scavenger and a foaming agent when using this equipment. However, the appropriate amount is unknown. Therefore, we investigated a method to easily estimate the amount of chemicals suitable for flotation treatment from the physical properties of raw fly ash. It is obvious that efficient treatment can be performed when the addition amount of scavenger and the addition amount of foaming agent is set to 10: 1, and that the addition amount of the agent can be accurately estimated by using the methylene blue adsorption amount of fly ash.

Keywords: Foaming agent, Scavenger, Ignition loss, Flocculent.

1 INTRODUCTION

In recent years, much progress has been made in Japan on the recycling of industrial byproducts. One such move has been toward the use of fly ash, a byproduct of coal-fired power generation, as concrete admixture. In our research described herein, we develop a technique for removing unburned carbon from fly ash by means of froth separation, a technology commonly employed in the mining industry to separate minerals from gangue (waste rock) (Takasu *et al.* 2007). With this technique, we begin by pumping a fly ash containing slurry into a cylindrical water tank. Then, by adding a scavenger agent and a flocculant to the slurry, we induce micro bubbling and, in this case, create a froth that contains a comparatively high proportion of unburned carbon. Finally, we recover the tailing ash, which thus contains a relatively low proportion of unburned carbon. The tailing ash obtained with this technique is essentially a fly ash for which ignition loss can be kept to 3.0% or lower, a characteristic that facilitates its application to concrete admixtures.

The authors and colleagues previously analyzed the costs entailed by fly ash improvement/separation by means of froth flotation. A breakdown of treatment costs reveals that materials, especially chemical additives (scavenger agent and flocculant), account for a high proportion of the total (Figure 1). Such costs can be substantially reduced by lowering the amount of such additives. An issue, though, is that with an insufficient amount of additives, it becomes difficult to obtain a tailing ash having an ignition loss of 3.0% or less; while, with an excessive amount of additives, it becomes difficult to keep treatment costs acceptably low. In our research, we seek to develop a method of readily predicting the properties of fly ash to result from additions of suitable amounts of chemical additives to the froth flotation process.

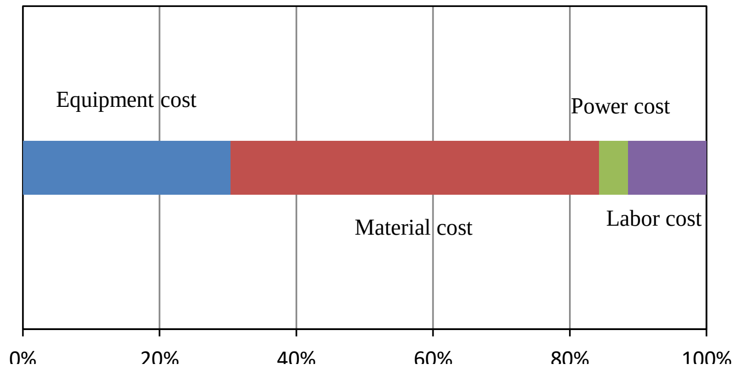


Figure 1. Breakdown cost of flotation treatment.

2 RELATIONSHIP BETWEEN ADDITIONS OF SCAVENGER AGENT AND ADDITIONS OF FLOCCULENT

2.1 Experiment Overview

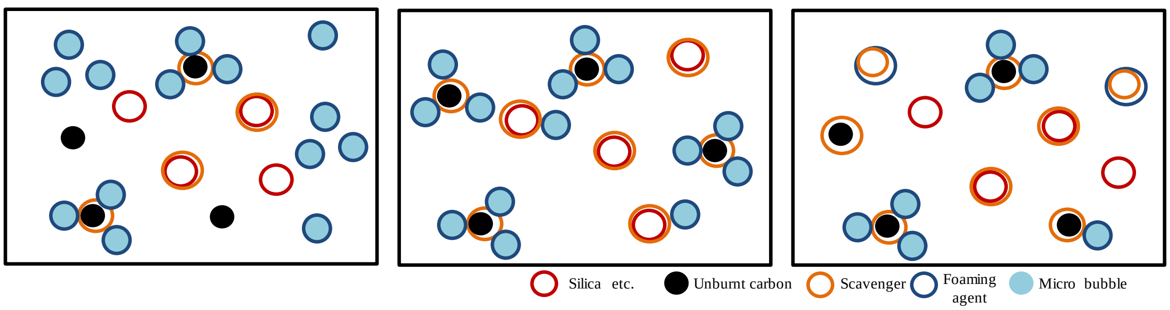
The effectiveness of an addition of a scavenger agent can vary depending on a simultaneous addition of a flocculant, and vice versa. In this research, we keep our flocculant additions at a constant amount will varying our additions of scavenger agent. And, by this, we investigate the impact of differing amounts of scavenger agent on the ignition loss of tailing ash recovered from the froth flotation process.

Table 1. Physical properties of raw material fly ash.

Fly ash	Production area	Ignition Loss	BET specific surface area (m^2/g)	MB adsorption amount (mg/g)
L	I	11.07%	7.90	4.14
S	I	12.81%	16.95	4.20
T	I	11.95%	16.48	4.25
M	II	4.43%	2.81	0.53
V	II	5.21%	5.07	1.64
N	III	8.48%	6.69	1.71
W	III	7.22%	8.74	1.78
X	III	9.16%	7.47	1.73
Q	IV	12.29%	17.22	2.32
U	IV	12.30%	11.11	2.46
P	V	7.58%	8.38	1.65
R	VI	4.52%	2.16	0.24

Presented in Table 1 are the properties of fly ash used within our research. For the work outlined in this chapter, we utilize Material S. Ignition loss with this material (i.e. fly ash) was measured to be 12.81%. We prepared three differing levels of flocculant additions to improve the properties of this fly ash: 0.1% (weight percent vs. fly ash), 0.2%, and 0.3%. Initially, we added 3.0% (weight percent) of scavenger agent and, from there, steadily added more scavenger agent until we could observe a clear trend in the ignition loss of the resulting tailing ash. Preprocessing for froth flotation consisted of a preliminary stirring stage, for which a 0.5L juice mixer was utilized to stir/mix a slurry of fly ash, tap water and scavenger agent for 3 minutes. The stirred sample was then put into a 16L container together with flocculant and, by means of a froth flotation tank, froth floated for 30 minutes.

2.2 Experimental Results and Discussion



a. less scavenger b. proper scavenger c. more scavenger

Figure 2. Amount of scavenger vs ignition loss of tail ash.

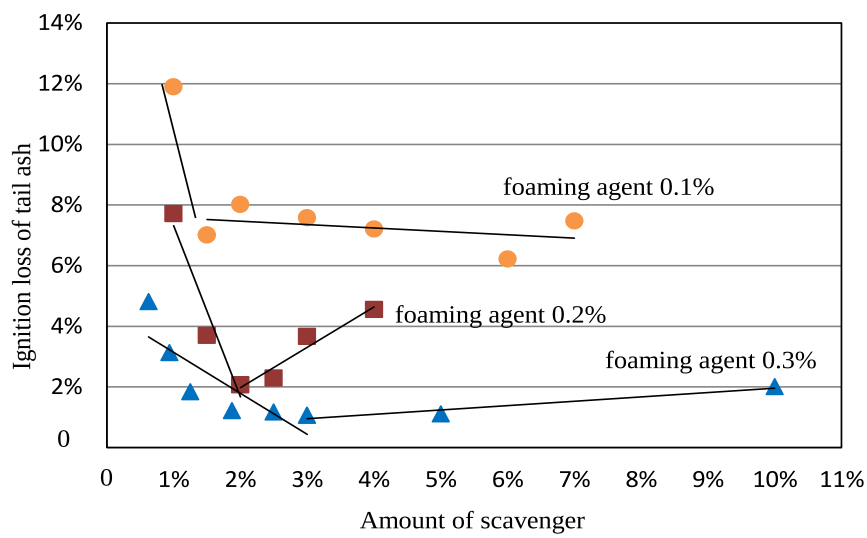


Figure 3. Mechanism to remove of unburned carbon.

Experimental results are shown in Figure 2. We see that tailing ash ignition loss tends to decrease with higher flocculant additions. With a constant 0.1% flocculant addition, the ignition loss decreases with increasing scavenger agent additions up to 1.5%. With further scavenger agent additions beyond the range, however, ignition loss remains essentially unchanged. With a constant 0.2% flocculant addition, ignition loss decreases with increasing scavenger additions up to 2.0%, at which point ignition loss reaches a minimum. Beyond that point, however, ignition loss increases with increasing scavenger additions. With a constant 0.3% flocculant addition, tailing ash ignition loss reaches a minimum at a 3.0% scavenger addition. From these results, it appears that adding scavenger agent and flocculant in a 10:1 proportion provides an efficient/effective way to reduce ignition loss.

Figure 3 illustrates our discussion of the manner in which the ignition loss of tailing ash tends to vary with differing additions of scavenging agent. Figure 3a shows a case in which there is a shortage of scavenging agent. Because of this paucity, not all unburned carbon surfaces can be coated by the agent. Uncoated carbon, thus unable to merged with/get removed by micro bubbles, remains in place. Conversely Figure 3c shows a case in which there as an excess of scavenging agent. Here, excess agent emulsifies and, in the process, consumes flocculant, thereby impeding the formation of microbubbles and, by extension, hindering process performance.

3 IMPACT OF CHEMICAL ADDITIVE AMOUNT ON TAILING ASH IGNITION LOSS

3.1 Experimental Overview

In this chapter, we examine the influence of differing amounts of chemical additions on tailing ash ignition loss by varying the amount of scavenger agent/ flocculant added to differing types of fly ash samples. Following on the results of the previous chapter, we set the ratio of scavenger agent addition (mass) to flocculant addition (mass) to 10:1. Of the differing types of fly ash covered within our research, we find that Material G has a comparatively low ignition loss. Materials D, E, H and I, on the other hand, have an ignition loss in excess of 5.0% and would thus be expected to have a deleterious impact on the fluidity and air entrainment characteristics of mixed concrete. The other materials have an ignition loss in excess of 8.0% and are thereby unsuitable for use as not only a concrete admixture, but even as an aggregate substitute. The procedure for froth flotation here is the same as that of the previous chapter.

3.2 Experimental Results and Discussion

Figure 4 shows relations between the amounts of scavenger agent/ flocculant additions and tailing ash ignition loss. For each of the fly ash materials, ignition loss tends to decrease with increasing amounts of these chemical additives. This said, depending on the type of fly ash, the effect on ignition loss can vary substantially, even at essentially the same levels of scavenger agent/flocculant additions. Setting control (target) values for tailing ash ignition loss to 2.0%, 1.5% and 1.0%, we determine (by linear interpolation) the amounts of scavenger agent additions necessary to reach those values (we hereafter refer to these amounts as the amount of scavenger agent necessary to attain, respectively, 2% ignition loss, 1.5% ignition loss, or 1.0% ignition loss). Interpolation results are shown in Figure 5. Likewise, Figure 6 shows relationships between these necessary amounts of scavenger agent and fly ash properties.

Within Figure 6, we observed a positive correlation between Brunauer-Emmett-Teller (BET) surface area of the fly ash and the amount of scavenger agent necessary to attain 2% ignition loss, although we also note that the cross-correlation is comparatively weak. In contrast, the correlation between methylene blue (MB) absorption amount and the amount of scavenger agent necessary to attain 2% ignition loss is both positive and comparatively strong. These results suggest that the apparent relation between BET surface area and scavenger agent necessary for 2% ignition loss is spurious (due to lurking variables). Here, the methylene blue adsorption amount, we believe, serves as a more suitable parameter for estimating the amount of chemical additives necessary for froth flotation. As a factor behind this result (i.e., as a factor for why the methylene blue absorption amount is highly correlated with the amount of scavenger agent necessary to attain 2% ignition loss), we note that methylene blue has a molecular weight of approximately 320, which is close to the molecular weight of scavenger agents (170 to 254). We thus infer that methylene blue adheres to fly ash particles during testing in much the same way as scavenger agent adheres to fly ash particles during froth flotation, a similarity that acts to raise the correlation between them. SEM photographs of Material P and Material Q are presented in Figure 7. Unburned carbon on the surface of Material P is comparatively smooth, while that on the surface of Material Q is deeply corrugated.

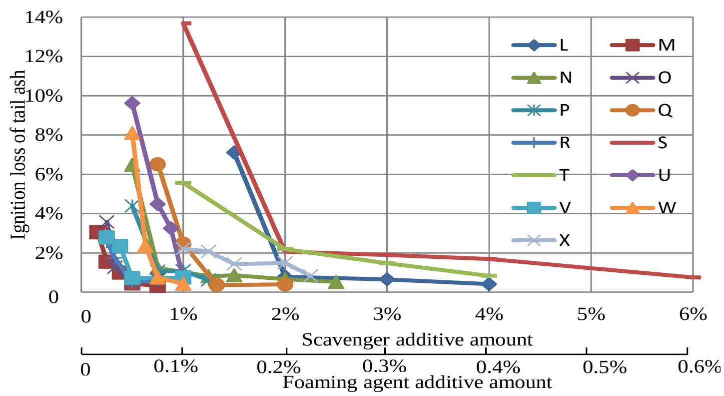


Figure 4. Amount of drug vs ignition loss of tail ash.

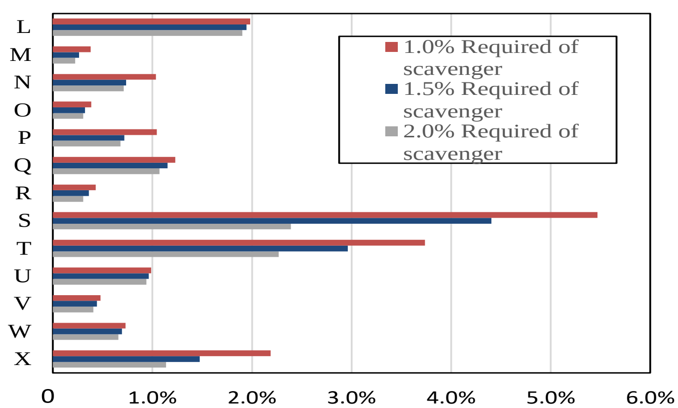
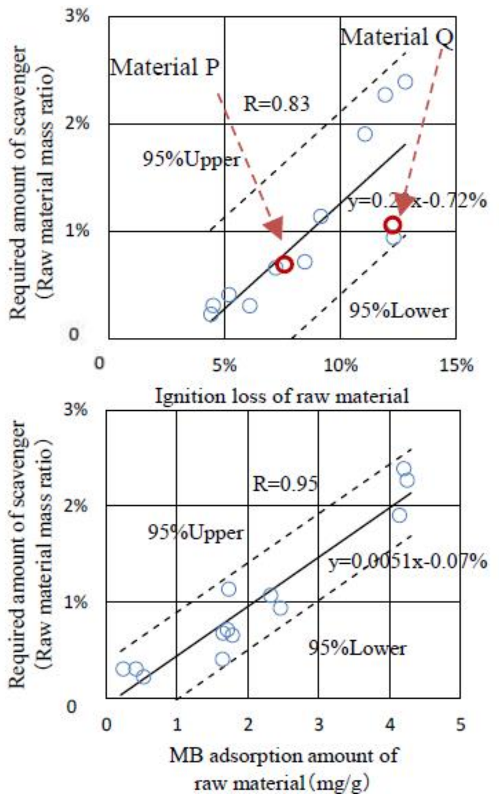


Figure 5. Physical properties of raw material fly ash vs required amount of scavenger.

Referring to Figure 6, we see that values for Material P remain close to the best-fit line, while those for Material Q are widely scattered. This, we infer, reflects differences in the way that scavenging agent adheres to unburned carbon. If the surface of the unburned carbon is highly corrugated, it requires that much more scavenging agent to cover. Thus, with a given (set) amount of scavenging agent, a corrugated surface would not be covered to the same degree of uniformity as a smooth surface; and, as a result, a coated corrugated particle would not adhere to a microbubble with the same degree of stability as a coated smooth particle.



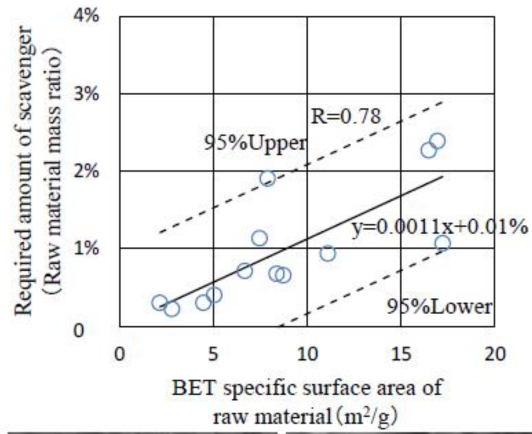


Figure 6. Physical properties of raw material fly ash vs. required amount of scavenger.

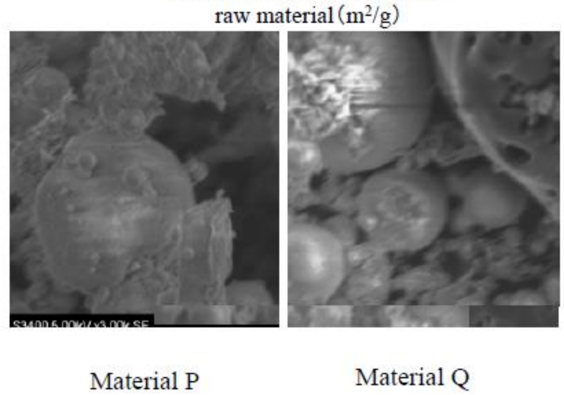


Figure 7. SEM Image of raw material fly ash.

4 CONCLUSION

- When using approximately equal amounts of scavenger agent, the ignition loss of the resultant tailing ash is lower with higher additions of flocculant.
- Adding scavenger agent and flocculant in a 10:1 proportion is thought to offer an efficient/effective way to reduce ignition loss.
- Even with essentially the same amount of chemical additions, the effect on ignition loss can vary substantially depending on the specific type of fly ash material.
- Measurements of methylene blue adsorption amount are thought to serve as an accurate indicator of the amount of chemical additives necessary for froth flotation.

Acknowledgements

The authors acknowledge the assistance in this work provided by Mr. Eiji Mikura and Ms.Ikumi Otsuki.

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